FUTURE DATUM

Progress in Rehabilitation Science

SHORT COMMUNICATION

Practically Useful Pole Exercise in Rehabilitation for Improved Rib Cage Flexibility

Akito MORIYASU[1,2], Hiroshi BANDO[3,4*], Mitsuru MURAKAMI[5]
[1]Rehabilitation Research Group for body and heart in Shikoku, Kagawa, Japan
[2]Akiboshi Bright Star training rehabilitation center, Kagawa, Japan
[3]Tokushima University / Medical Research, Tokushima, Japan
[4]Japan Masters Athletics, Tokushima division, board, Tokushima, Japan
[5]Japan Masters Athletics, Kagawa division, vice-president, Kagawa, Japan
*Corresponding Author email: pianomed@bronze.ocn.ne.jp

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INTRODUCTION

In recent years, medical and social needs for various rehabilitation have been increased. The reason for this is that medical treatment and research have been gradually developed, and the level of the actual rehabilitation has been elevated and these effects have been increased compared to previous situation. Related subjects include patients with orthopedic problems, cerebrovascular accident (CVA), dementia, mild cognitive impairment (MCI), masters athletes, younger athletes, and so on (Zhao, 2019). Thus, in addition to various orthopedic and neurosurgery patients receiving medical treatment at hospitals, the number of people from sports clubs, fitness clubs, and semi-professional athlete clubs have come to receive adequate rehabilitation nowadays.

Rehabilitation can restore function and improve muscle strength in any portion of the body. Among them, most important part would be the trunk than the extremities (Sung, 2016). It is because that the trunk is the starting point of various movements, and a variety of related factors have been involved in the movement. The trunk consists of the spinal column, rib cage and pelvis, and there are many joints such as facet joints, vertebral joints and sacroiliac joints (Izzo *et al*., 2012). Consequently, it is indispensable to optimize the joint function of the trunk where there are certain joints in order to perform highly accurate motion (Hoffman and Gabel, 2013; Panjabi, 1992).

It is important to maintain and improve the motor function of the trunk by some effective methods. For this purpose, it is necessary to operate many joints and muscles simultaneously existing in the spinal column, rib cage and pelvis, and to input appropriate stimuli to the related receptors (Sung, 2016; Panjabi, 1992). There have been research for the kinematic data on the thoracic spine, lumbar spine and pelvis, and for the coupling angle about thorax–lumbar, lumbar–pelvis and thorax–pelvis coordination patterns (Sung, 2016). Then, it is recommended to make the trunk joints and muscles move around in three-dimensional way. Consequently, exercise therapy has been an effective way to improve the motor function of the trunk (Liebsch and Wilke, 2018). There are a variety of exercise therapy for the trunk, such as weight training, inner muscle training, stretch poles, and others.

Authors and co-researchers have continued clinical practice and research for a variety of subjects, including patients with CVA and orthopedic problems, masters athletes and professional athletes of baseball and football. Among a variety of therapy and workshop, we have continued to apply pole exercise training (Moriyasu *et al*., 2017 and Murakami *et al*., 2019). When the pole exercise is conducted, an aluminum pole called Moriyasu pole has been used. Its characteristic point is that it can be easily adjusted from a short to long pole (combination with 4 parts, 80, 100, 140, 160cm) by combining four pieces.

As a basic exercise, it includes 6 kinds of movements, such as i) lateral bending, ii) axis rotation, iii) warp & rounding (bend & extension), iv) rotation, v) spiral motion back & forth, and vi) sliding (Figure 1). These movement can also add stretching for muscles of the body. Concerning the posture of the subject, there are some options such as standing, half-sitting and sitting positions.

Applying pole exercise training, there have been beneficial response for the attending subjects (Moriyasu *et al*., 2017 and Moriyasu *et al*., 2018). What is the reason why the pole exercise can effectively pull

out the trunk's motor functions and improve flexibility and mobility of body functions? There are three possible reasons for these phenomena (Moriyasu *et al*., 2018).

The first is a change in the position of the pole. This training will change the location of the pole (Moriyasu *et al*., 2018 and Kurihara et al., 2016). Basically, there are three types, such as bearing, pinching and gripping, associated with fine adjustment. Because it can be adjusted along the minute motion segment of the spinal column, it can effectively induce the articulation in each motion axis (Moriyasu *et al*., 2018 and Moriyasu and Bando *et al*., 2018). In this way, it is possible to promote difficult three-dimensional movement.

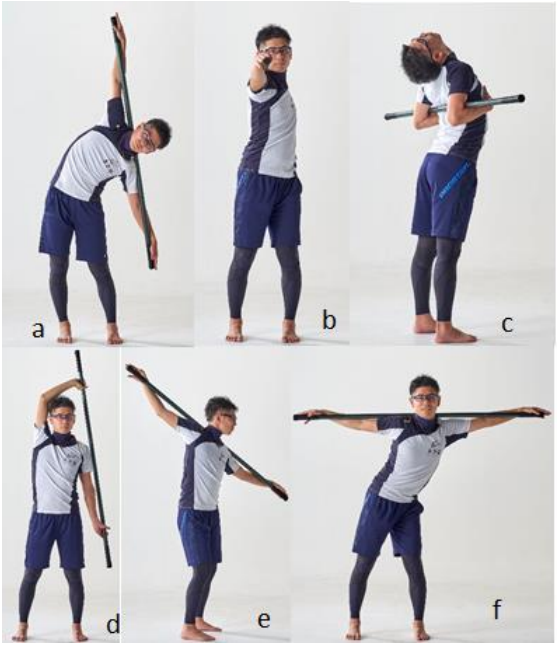

Figure 1: Six basic types of pole exercise. There are 6 basic movements, which are a) lateral bending, b) axis rotation, c) warp & rounding (bend & extension), d) rotation, e) spiral motion back & forth and f) sliding.

The second is improvement of the rib cage mobility. The thorax weight accounts for about 40% of the trunk mass, and it may appear to be a single mass with no movement. However, there are actually significant movements. In other words, the thoracic joint motion includes axial rotation motion at the radial head joint and sliding motion at the costotransverse joint (Zhang et al., 2016). Conventionally, the movement of the upper rib has been called pump-handle motion, and it is observed in the front-rear direction, which is the sagittal plane [13]. On the other hand, the movement of the lower rib has been called bucket-handle motion, and it is observed in the left-right direction, which is the frontal plane (Zhang et al., 2016 and Donley and Loyd, 2019).

As an exercise therapy for all these rib cages, the pole training has been effective. Especially the spiral movement can induce the movements of the radial head joint and the costotransverse joint effectively. Consequently, the mobility of the thorax can be expected to be improved by the pole exercise.

The third is the exercise in various postures. Humans are living and moving upright bipedally after the evolution of the mammalian. Among them, the trunk always maintains the balance of the body center of gravity while coordinating with the muscles of the lower limbs. In other words, the necessary muscles are properly contracted when moving the joints. In that case, there are many anti-gravity muscles that keep the balance of the body, and it is necessary to maintain an appropriate isometric contraction state (Capano *et al*., 2019). These muscles include the erector muscles of spine, multifidus, iliopsoas muscle, gluteus medius and deep external rotator muscle.

Pole exercise contributes to smooth movement of ribs, cervical/ thoracic/ lumbar vertebrae related to the thorax cage. Among them, when rotating the thoracic vertebrae, the movement of the costovertebral joint and the costotransverse joint would be important. In the case of right rotation, the right costotransverse joint is rotated backward and the left costovertebral joint is rotated forward. The movement of the rib accompanying this thoracic spinal rotation is called Rotation Dance (Lee, 2015).

Authors have investigated the difference of two groups with or without pole exercise intervention Moriyasu *et al*., 2018 and Kurihara *et al*., 2016). We studied thoracic flexibility/stability by using the Spinal Mouse which has been reliable device (Piancino *et al*., 2019). As a result, the range of motion (ROM) was larger in the case of pole exercise on the shoulder than at the armpit (Moriyasu and Bando *et al*., 2018 and Kurihara, 2019).

A study of pole exercise of flexi-bar and non-flexi-bar was reported with muscle activity of the rectus abdominis (RA), external oblique (EO), internal oblique (IO) and erector spinae (ES) (Chung *et al*., 2015). The result showed rather more useful in flexi-bar for the activation of trunk muscles.

In summary, pole training makes the rib cage move smoothly. People show various postures in daily life and sports. For example, there are standing, half-sitting and sitting positions as well as standing on one leg and lunge position. Thus, pole exercise method would be one of the effective rehabilitation methods for trunk and joint movements in various situations. We expect that this report would become useful reference for research of pole exercise and rehabilitation in the future.

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